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ON A GENETIC SYSTEM OF SAND DUNES, INCLUDING TWO NEW TYPES

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In the earlier literature about sand dunes and in most text-books of geology and physical geography a distinction is made between *seashore* and *continental dunes.* Sokolow[1] was the first to mention a new type of dune, the *river dune.*[2] The creation of this type caused a certain confusion in what up to this time had been a very simple system. He could not place this new dune type either among the seashore dunes or among the continental ones. Because, if the river dune appears on deltas which extend into the sea, it is no longer topographically a continental, but a seashore dune, although genetically its material is continental. The difficulty is still greater if the waste of the river as well as the sand thrown out by the sea has partaken in the formation of the dunes on a delta. A new type of dune has thence arisen, which the writer is inclined to call a *mixed dune.*

According to his opinion it would be far better to discard the simple system mentioned above, which may be called a geneto-topographical one (this term takes into account both the genesis and the topographical location of the dunes) and to classify the dunes genetically, according to their origin. Thus we could secure a place in the system for the river dune and could include new forms. In this new grouping we differentiate between dunes whose existence depends upon the wind and those to whose creation other factors have also contributed.

The continental dunes are purely æolian, as for instance those of the desert and those occurring close to the seashore. The material of the latter, fine diluvial sand, is blown out by the seabreeze from the wall of the high shore and deposited either on the margin of the upland or a short distance inland. The writer has observed two such cases on the little island Hiddensoe (54° 30′ N. and 13° 5′ E.) in the Baltic, west of Rügen (North Germany). As described elsewhere[3] the writer has proposed two new names: *cliff margin* and *high shore dunes* (Figs. 1 and 2).

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[1] N. A. Sokolow (transl. into German by Andreas Arzruni): Die Dünen, Bildung, Entwicklung und innerer Bau, pp. 147–157. Berlin, 1894.

[2] F. Solger (Studien über nordostdeutsche Inlanddünen, *Forschungen zur deutschen Landes- und Volkskunde*, Bd. XIX, Heft 1, pp. 83–86, Stuttgart, 1910) narrows the application of the term river dune. According to him only a portion of the dunes of this type get their material from the waste transported by the river. Others are created by the weathering of rocks which build up the river basin. These dunes are sometimes older than the river itself.

The diluvium outcrops on the northern side of the hilly part of Hiddensoe, at the slides of the high shore. The seabreeze blows out the sand, carries it up the cliff margin and deposits it there, compelled to do so by the little pine wood standing in its way (Rennbaum or Bismarckdüne is the local name of this territory). The form of these cliff margin dunes is no longer intact. Human and natural agencies have disturbed their original development and have thus created the character of the *wild dune,* which no longer shows the two characteristic slopes of each dune: the smoother windward and the steeper lee side. It is in vain that we measure their declivities; we cannot draw any sure conclusions from these indistinct forms.

If not hindered on its way by some greater obstacle, the sand will settle down a short distance inland from the margin of the high shore at the foot of some juniper bush. The dune (high shore dune) thus formed on the declivity is not yet perfectly developed; the sand has not yet entirely covered the juniper bush. The characteristic slopes, however, are already sharply marked, and therefore there can be no objection to calling it a dune.

The following table gives the dimensions of three such dunes:

No.	Length of the		Mean breadth in cm.	Crest height in cm.	Direction of the major axis	Angle of declivity		Angle of declivity of oblique slope of the high shore
	windward side	lee side				of windward side[4]	of lee side	
	in cm.							
1	420	80	280	62	S. 55° E.	29° N.	33° S.[5]	20° N. approx.
2[6]	560	60	290	38	S. 49° E.	29° N.	36° S.	
3	350	70	220	55	S. 56° E.	29° N.	34° S.	

In contrast to the group of æolian dunes stand those of hydroæolian origin. Under this category we include the seashore[7] and the river dunes. In their formation water has washed the material out of the rock and turned it into sand, which, while being trans-

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[3] Michael Haltenberger: Über Art und Umfang des Landverlustes und Landzuwachses auf Hiddensoe bei Rügen (Dissertation, Univ. Greifswald), pp. 69–72. Budapest, 1911.

[4] This includes the angle of declivity of the high shore (20°).

[5] Indistinct on account of vegetational covering.

[6] This dune was formed by the amalgamation of two or three smaller ones.

[7] As the dunes which may be found on lake shores are identical with those of the seashore, we need not mention them especially.

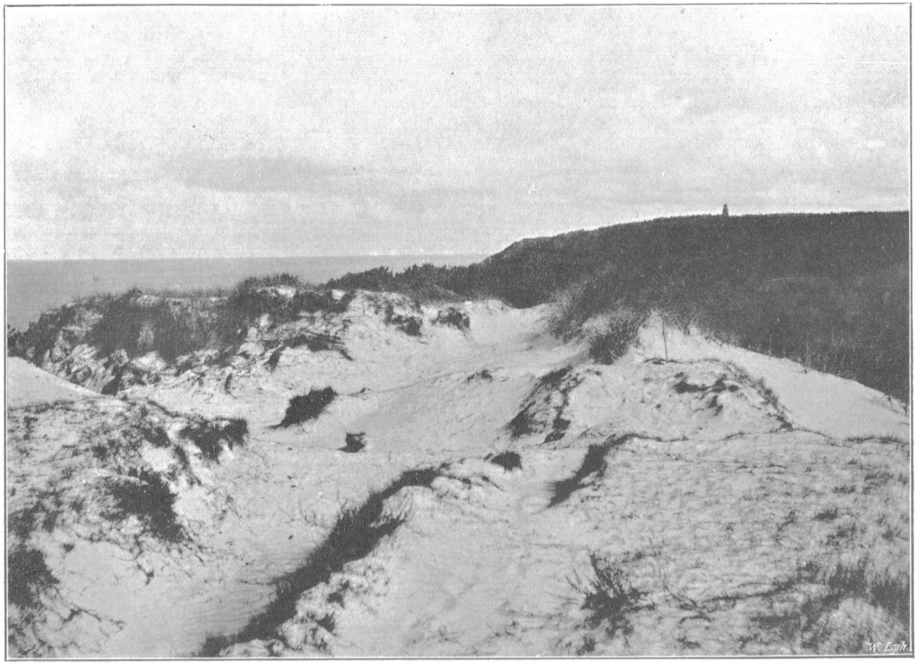

Fig. 1.—Cliff Margin Dunes on the Northwestern Part of the Diluvial High Shore of the Island of Hiddensoe, near Rügen, Baltic Sea. Photograph by the author.

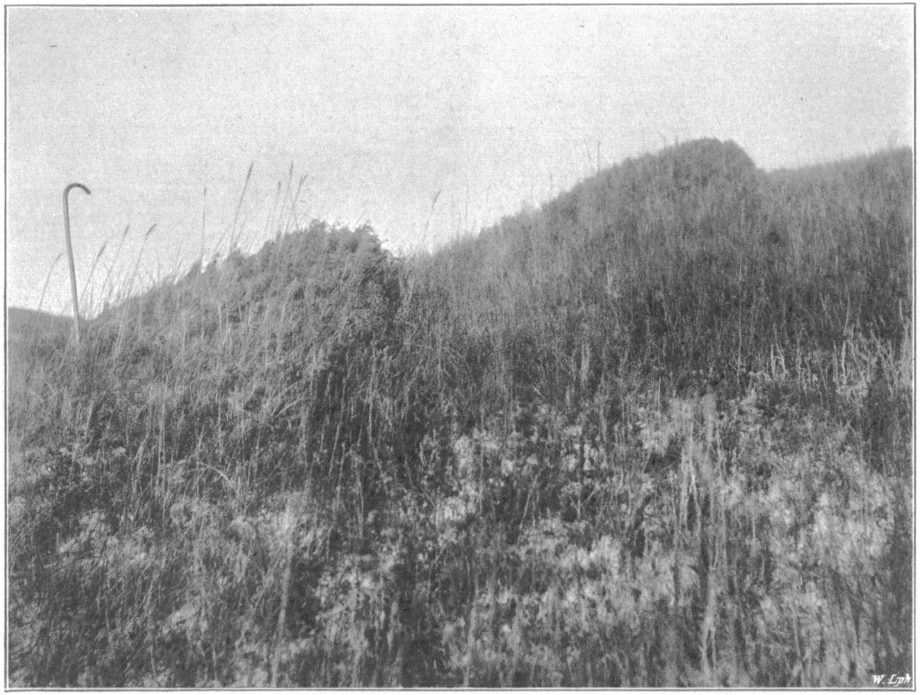

Fig. 2.—High Shore Dunes on the Northern Part of the Diluvial High Shore of the Island of Hiddensoe, near Rügen, Baltic Sea. Photograph by the author.

ported partly by the waves, partly by the inundation of the rivers, partly through the sandbanks under the immediate influence of the air, has been heaped up into dunes by the wind. Consequently water and wind are the two main factors in the creation of hydro-æolian dunes; the one prepares the material, the other forwards it.

The value of the proposed genetic classification, it is suggested, is that it does away with the difficulties of the geneto-topographical system and also gives a proper place to the river dune, which hitherto has occupied only an indefinite middle ground between the seashore and the continental dune.

The relation of these two systems is shown in the following table:

Geneto-topographical system	Genetic system
continental dunes	æolian dunes (1) continental (2) seashore (a) cliff margin (b) high shore
river dunes (mixed dunes) seashore dunes	hydro-æolian dunes (1) seashore (2) river

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